

Environmental Monitoring During The Construction of The Jebel Ali New Container Terminal

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Project

As part of a major expansion of Jebel Ali Port, Dubai, Stage I involves the construction of four container berths, dredging of a harbour basin to -14m DMD (Dubai Municipality Datum), the construction of protective breakwaters and revetments, the reclamation of approximately 350 hectares of land and the development of approximately 190 hectares of land. This new facility has been designed to service Super-post-panamax vessels with a length of 380m and a capacity of 12500 teu. An allowance has been made for future dredging of the basin to -18m DMD.

During the construction phase of the project the Contractor was committed to adhere to very strict environmental regulations. The implementation of a comprehensive monitoring program allowed measuring the effectiveness of the management measures which were implemented.

The initial dredging operations consist of dredging a trench of approximately 2,700 m length with a bottom width of 14.25 m on a depth of 20.20m DMD (see figure 2). During the first phase the Cutter Suction Dredger (CSD) *Marco Polo* will be dredging till approximately Chainage 1,400. This will allow the commencement of the Quay wall construction by others.

Monitored Parameters

Hydro-meteo parameters

The most important parameters that highly influence turbidity levels and the extent of the sediment plume are the hydro-meteorological conditions: current speed and direction, significant wave height, wave period and direction, seawater temperature and waterlevel.

Turbidity monitoring

Fixed monitoring stations

A total of 7 monitoring platforms transmit realtime turbidity values which can be accessed through a dedicated website:

- A row of 4 platforms is located eastward from the area to be dredged where 29 NTU was specified as threshold value.
- In the vicinity of 3 industrial plants with operational seawater intakes 10 NTU was specified as threshold value.

Synoptic monitoring at adjacent areas

The daily synoptic turbidity occurs at 10 locations:

- At 3 locations to the West of the project area synoptic monitoring was conducted at high tide and 59 NTU was specified as threshold value.
- At 7 locations to the North and East of the project area synoptic monitoring was conducted at low tide and 29 NTU was specified as threshold value.

Synoptic monitoring near the dredger

The dredging operations of the CSD *Marco Polo* are monitored at 150 m and 1000 m downcurrent from the dredging location. At 1000 m down current from the dredging location 29 NTU was specified as threshold value.

Synoptic monitoring near the relocation area

Near the relocation area the operations are monitored at 150m and 1000m downcurrent from the discharge locations. At 1000m down current from the discharge locations 29 NTU was specified as threshold value:

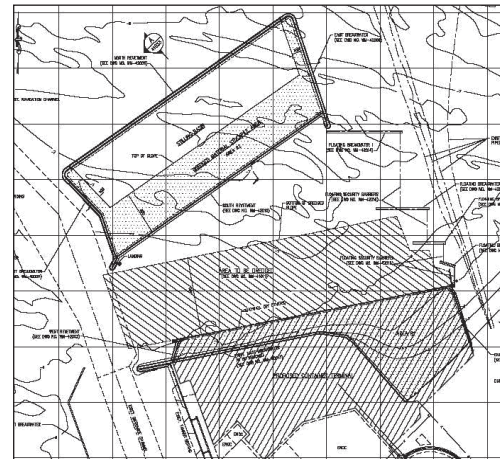


Figure 1: Project layout.

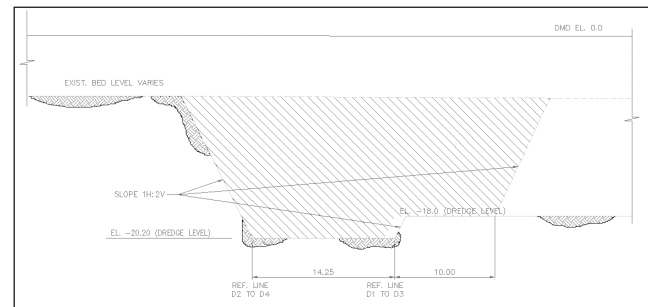


Figure 2: Trench design.

Mobile monitoring

Next to the contractual agreed upon turbidity monitoring, the Environmental Monitoring Team planned and executed additional surveys. The main reason was to gain further insight in the behaviour of the sediment plume originating from the 'Marco Polo'.

Fall velocity determination

In the initial Turbidity Monitoring Plan it was proposed to take 3 water samples at 150m distance downcurrent from the Dredger. However after a first laboratory test, it seemed that the watersample only had a very small amount of TSS. In order to have a better and more relevant understanding of the fall velocity of the dredged material the water samples were taken at the centre of discharge location from the barges.

Water quality analysis

Water analysis serves two goals, first the verification of the previously established conversion coefficients for the different turbidity sensors and second bio-chemical parameters to assess the dredging related impact on the coastal environment.

The following parameters are measured:

- Total Suspended Solids (TSS)
- Ammonia (NH_3)
- Nitrate (NO_3)
- Total Phosphorous (P)

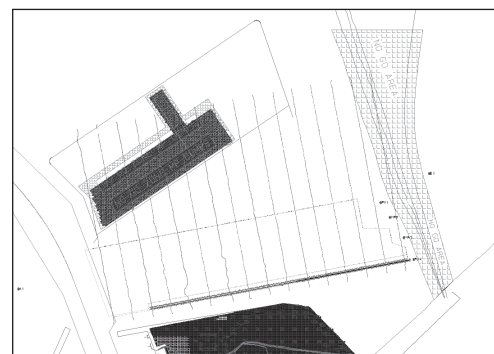


Figure 3: Turbidity survey grid.

Monitoring Setup And Working Grid*Hydro-meteo parameters*

On the bottom of the seafloor next to 2 monitoring beacons Nortek AWACs are installed. This kind of current profiler uses the Doppler principle to measure current velocity by transmitting a short pulse of sound, listening to its echo and measuring the change in frequency of the echo. The system is also used to measure the wave amplitude, direction and period. An embedded thermistor monitors the seawater temperature.

*Turbidity monitoring**Fixed monitoring stations*

Fixed monitoring stations are used to monitor the suspended solids concentration at fixed locations and depths over longer periods at preset time intervals.



Picture 1: AWAC sensor and its mounting frame.

After activating the datalogger the system becomes an autonomous monitoring and registration system. The readings of all the connected sensors are broadcasted by the interfaced telemetry link at the set interval and at the same time all data is stored in the onboard datalogger. The receiver station at the office is interfaced to a processing computer.

Biofouling of turbidity sensors is a major concern in tropical waters and therefore regular cleaning of the sensors is of utmost importance. By applying antifouling as described in the manufacturer's recommendations per particular sensor the cleaning interval may be reduced.

Synoptic monitoring and mobile monitoring

The survey launch (DN71) is used to conduct synoptic and mobile monitoring surveys and perform synoptic sampling. The equipment set up for mobile monitoring is identical to the synoptic measurements. The only difference lays in the working method. Synoptic monitoring takes place at several predefined locations and while measuring the DN71 stays on those locations. Mobile monitoring takes place at a constant speed of 2 knots along predefined survey lines

The OBS is attached to a cable on a winch operated by computer or remote control. The data-signals from the sensor are interfaced via the electro-mechanical cable through the winch to the survey computer and logged together with the easting and northing from the dgps-receiver and the seabed depth from the survey echosounder. NTU values are available in real time and are logged at the same time. Upon completion of the survey



Picture 2: Monitoring platform.

the data is processed at the office, where the recorded data is combined with other parameters.

Fall velocity determination

A Settling Tube is employed for sedimentation analysis. By measuring the elapsed time between corresponding measured turbidity values for the different sensors in the cylinder the settling velocity can be determined by dividing the distance between the sensors by the elapsed time.

Water quality analysis

Total suspended solids

For both Top, Mid and Bottom depth of the water column 1 liter samples are taken with the use of a peristaltic pump. The end of the tube is attached near the photo detector and signals are logged while sampling. A well-mixed 1 liter sample is filtered and the residue retained on the filter is washed and dried to a constant weight at 103 to 105°C. The increase in weight of the filter represents the total suspended solids.

Bio-Chemical analysis

Analyses to determine Ammonia (NH₃), Nitrate (NO₃) and Total Phosphorous (PO₄) were executed by a local laboratory.

Results

Hydro-meteo parameters

Tidal currents

The tides in the study area are semi-diurnal and are the driving factor behind the relatively weak currents.

Two main directions can clearly be deduced for the lower part of the water column: mainly towards 230-240°, corresponding with high tide period and towards 50°, corresponding with low tide period. Near the surface, the current direction is more variable, going from the east towards the southwest. For both January and February a more outspoken different surface current was observed. Winds blow dominantly from the northwest throughout the year, however during winter are these winds noticeable stronger, the gale-force 'shamals'. The most of these shamal events occurred in January, which is also reflected in the continuously increased current speed.

Wind and waves

The occurrence of 'shamals' is clearly reflected in the significant



Picture 3: survey vessel DN71.

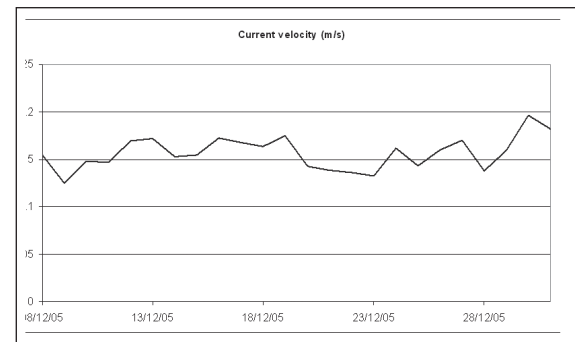


Figure 4: Current velocity for December 2005.

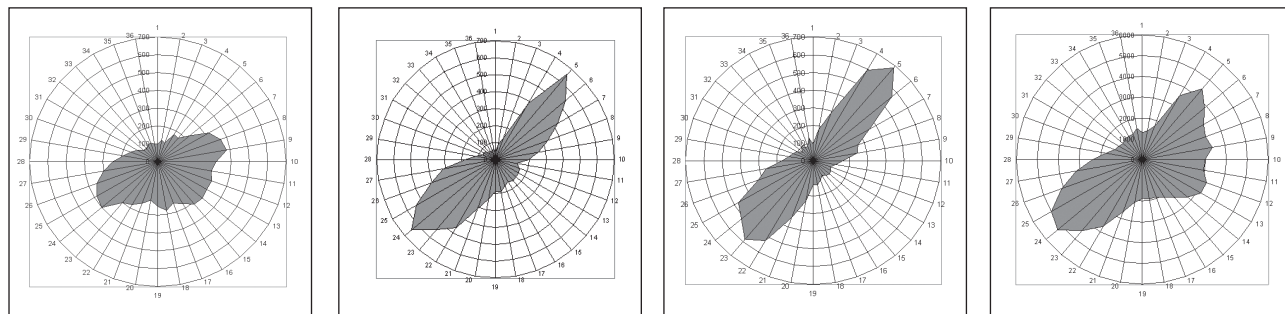


Figure 5: Prevailing current directions for December 2005 (A: at -1m below the sea surface, B: at mid-depth, C: at +1m above the seabed, D: monthly average for the three depths).

wave heights, both in their direction as in the significant wave height. The significant wave height exceeded several times 1m during this 3 month period. Each of these periods correspond with a shamal event and mostly were the dredging activities paused. Synoptic turbidity monitoring was also halted during these periods. The monitoring beacons measured a sharp increase in NTU values. Due to this extreme events one could notice numerous cloudy patches in the sea along the coastline of Dubai. These arose not specifically from dumped or dredged materials but from local shallow spots on the coastal terrace where the waves 'touched' the seafloor.

Turbidity monitoring

Fixed monitoring stations and Synoptic Monitoring

There are two main causes for elevated turbidity levels, both due to the natural environment in which the equipment is deployed : marine growth on the sensor and increased turbidity values after bad weather.

The clear seawater in front of Jebel Ali port is characterized by a very low suspended sediment concentration, approaching 0-values. Compared to those normal background values, the above mentioned natural impacts cause a temporary but mayor increase in turbidity levels.

None of the occurrences of high NTU values could be related to the dredging and relocation activities.

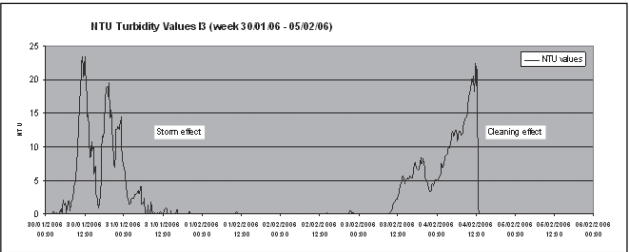


Figure 6: Influence of storm and biofouling on turbidity.

Mobile monitoring

Next to the contractual agreed upon turbidity monitoring, the Environmental Monitoring Team planned and conducte additional surveys. The main reason was to gain further insight in the behaviour of the sediment plume originating from the 'Marco Polo'. During a period of 3 months (Dec 2005 and Jan – Feb 2006) turbidity data was gathered in a survey grid covering the region of interest.

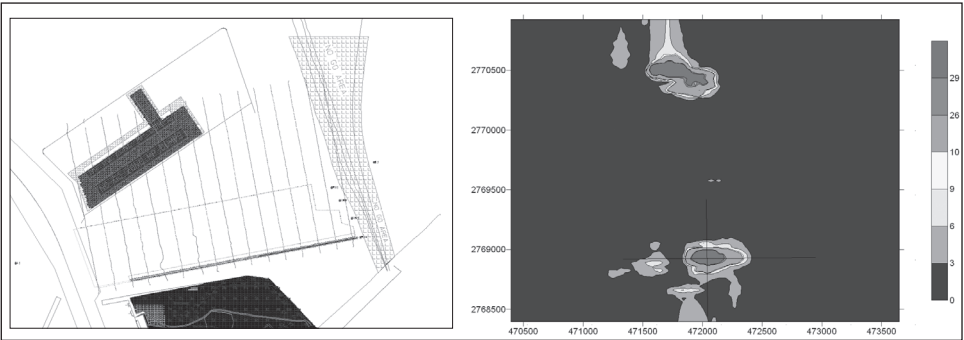


Figure 7: Example of interpolated turbidity map.

Statistical analysis gives the spatial extent in eastern direction of the Marco Polo sediment plume.

NTU alarm levels	29 E	26 E	10 E	9 E
Distance from Marco Polo (m)	173	199	374	392

Table 1: location of NTU alarm levels.

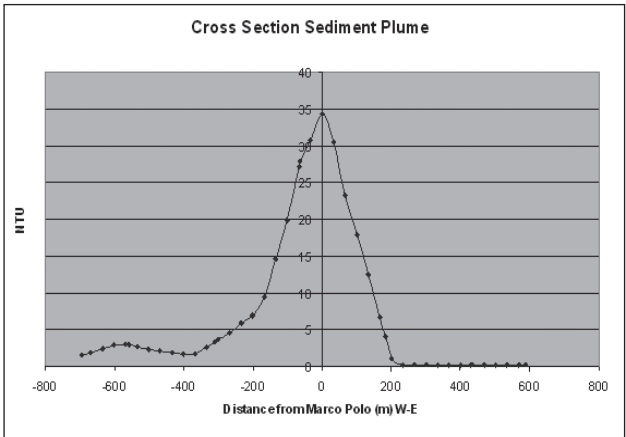


Figure 8: Plume extent.

The results of the chemical analyses, conducted on the samples which were taken during this phase of the project are listed in the table below.

Fall velocity determination

The fall velocity of the dredged material was determined during separate settling tests. From the log files an average settling velocity of 6.3 cm/min was determined.

Water quality analysis

Total Suspended solids

Beside laboratory determination of the ratio NTU – mg/L, in situ information was gathered during weekly TSS analysis from seawater samples taken in the dredging and dumping area simultaneously with the turbidity values. Taking all the measurements into account a conversion factor of 2.81 is obtained. When rejecting the average values increased or decreased with the standard deviation, a conversion factor of 2.43 is found, which confirms the initial value of 2.57 which was determined during the laboratory tests.

Nitrogen, Ammonia, Nitrate and Phosphate

2006	PO ₄ (mg/l)	NO ₃ (mg/l)	NH ₃ (mg/l)	Methodology
Week 4	0.02	0.9	<0.01	AWWA/APHA
Week 5	0.13	0.6	0.04	HACH
Week 6	<0.1	0.1	<0.1	HACH
Week 7	0.04	1.3	0.12	AWWA/APHA
Week 8	<0.1	0.6	<0.1	AWWA/APHA
Week 9	<0.1	1.3	<0.1	AWWA/APHA
Week 10	0.1	0.6	0.1	AWWA/APHA

Table 2 : Results chemical analysis.

Summary And Conclusions

This report provides an analysis and evaluation of the environmental impact during the initial dredging stage of the Jebel Ali New Container Terminal (6/12/2005 – 10/03/2006). Methods of analysis include continuous turbidity monitoring, weekly water sampling for chemical and suspended sediment tests, and the set up of a hydro-meteo database. The dredged trench material is relocated a few kilometers further offshore, into the Reclamation Area and the Stilling Basin. The generated sediment plume is monitored both by mobile and fixed monitoring.

During the trench dredging, the turbidity remained well within threshold levels imposed by the client. However with the CSD *Marco Polo* moving up closer towards the fixed monitoring stations, it has to be kept in mind that the monitoring platforms, which had to be installed very close to the dredging area due to safety reasons (outside the pipelines corridor), will be situated within the influence radius of the sediment plume.

The chemical composition of the seawater showed no significant variance due to the dredging.

When the dredging activities were halted during bad weather conditions, it was noticed that the levels of turbidity around the fixed monitoring stations were much higher than while dredging works were going on. Due to the enforced action of wind, wave and current, the sediment is brought into suspension. So these natural actors also have an impact on the natural increased turbidity and were causing values of suspended sediment in the seawater reaching the threshold determined for dredging activities. Already can be stated that under influence of bad weather much higher turbidity values are reached than dredging works have done up until now. Unfortunately the rough conditions at sea make it impossible to execute a synoptic monitoring at the same time to check and verify the turbidity values at the other mobile locations.

Biofouling of the optical scatter instruments results into over-estimated turbidity values. Every sensor needs regularly cleaning. With increasing seawater temperatures the biofouling will speed up. One has to consider to apply anti-fouling agents in order to control the growth of bacteria and algae.

In general it can be concluded that further detailed and thorough investigation is necessary seen the increasing importance of issues related to marine coastal environments, not only for this project, but also in other regions. The strict way in which this project is handled can be used as a model for future environmental monitoring programs and impact assessments.

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